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November 20, 2009

**Via ECFS**

Marlene H. Dortch  
Secretary  
Federal Communications Commission  
445 12<sup>th</sup> Street, SW  
Washington, D.C. 20554

Re: Notice of *Ex Parte* Presentation, GN Docket 09-51

Dear Ms. Dortch:

On behalf of Calix ("Calix"), and in accordance with Federal Communications Commission ("Commission") rule 1.1206(b), enclosed for filing in the above-referenced docket is a presentation that David Russell of Calix provided today to Rohit Dixit of the Commission's Office of Strategic Planning and Policy. The purpose of the presentation was to provide information regarding VDSL2 applications.

Should you wish to discuss the presentation further, please contact me.

Sincerely,



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*Counsel for Calix*

Attachment

cc: Rohit Dixit, FCC

# Evolving VDSL2 Applications

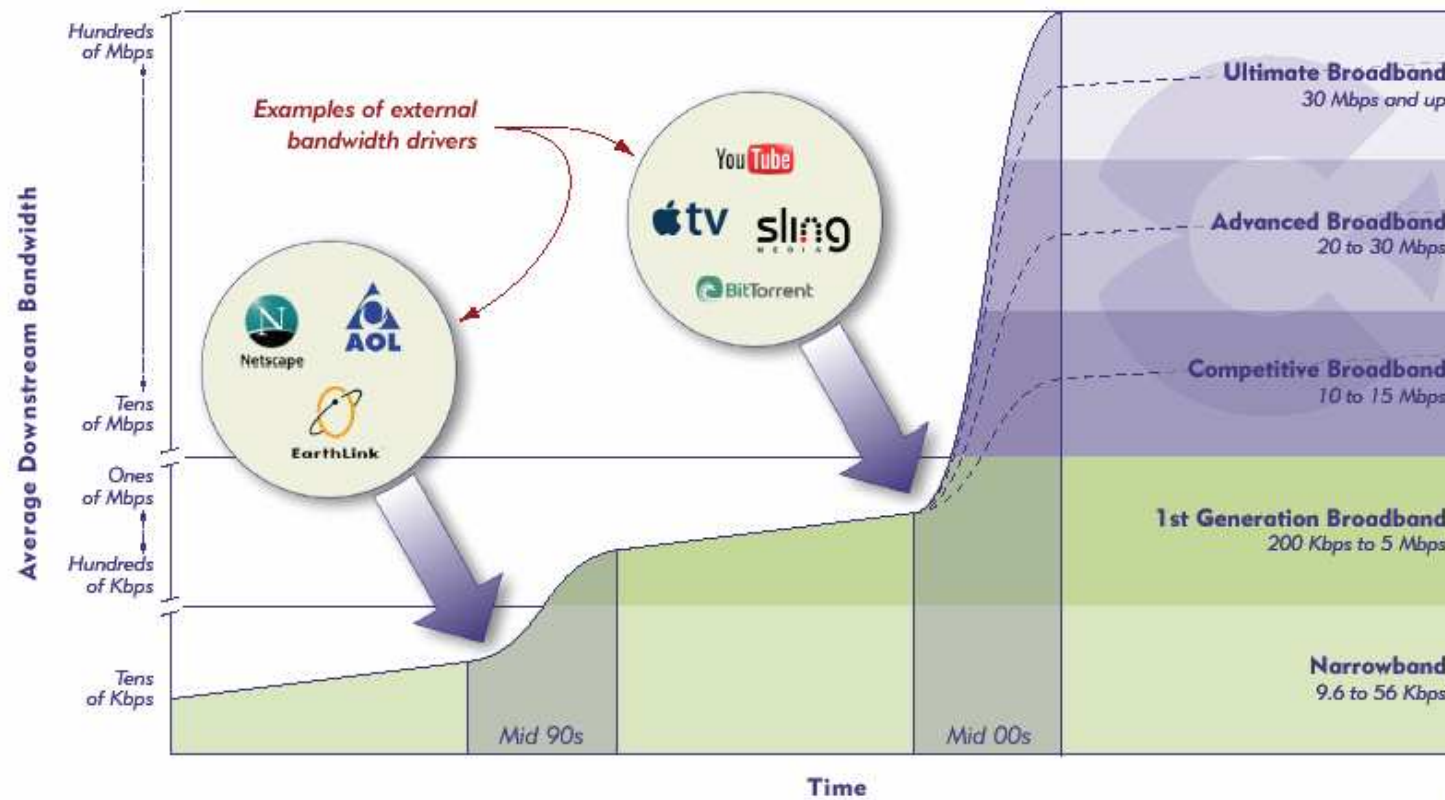
The information contained in this presentation is not a commitment, promise or legal obligation to deliver any material, code or functionality. The development, release, and timing of any features or functionality described for our products remains at our sole discretion.

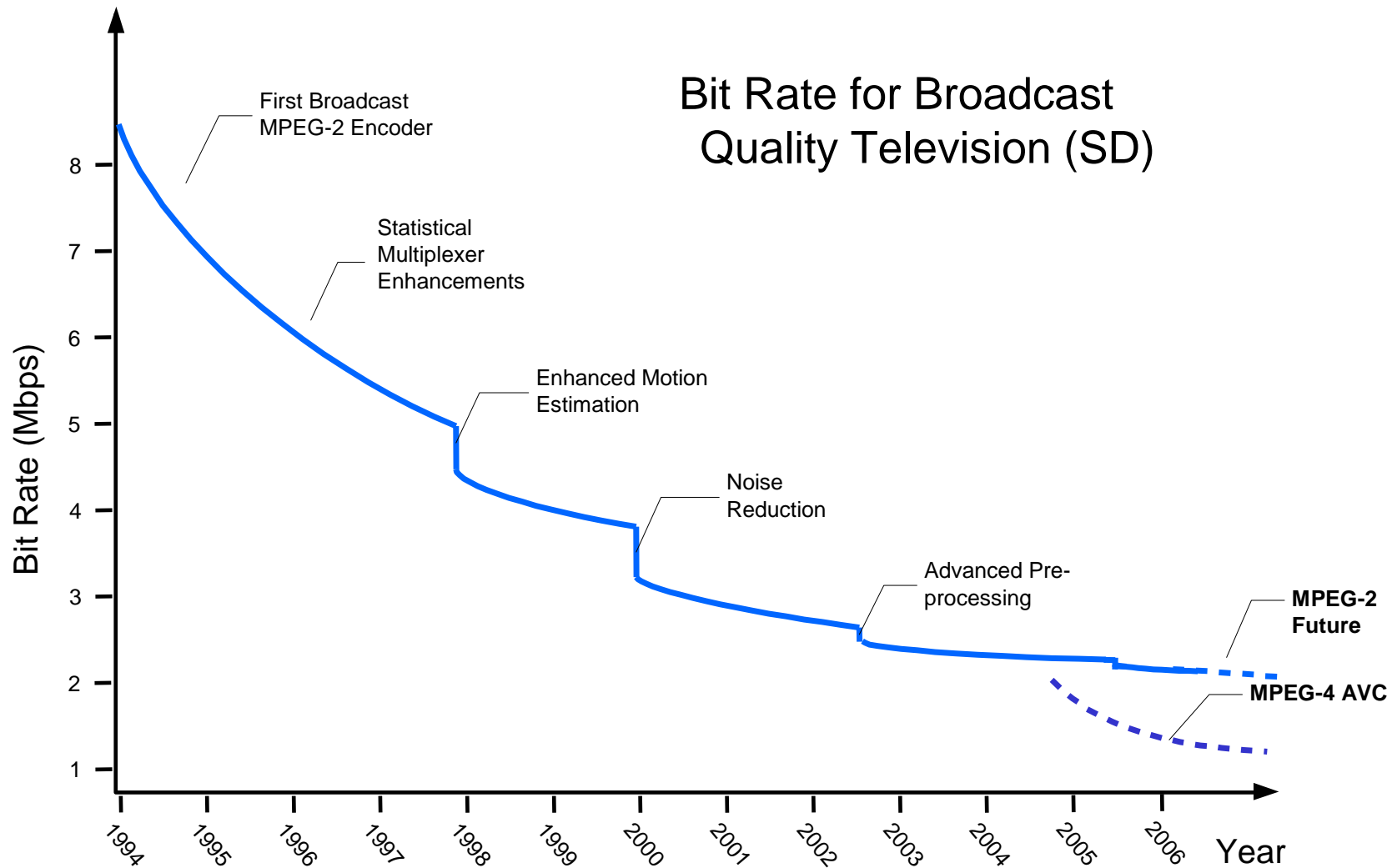


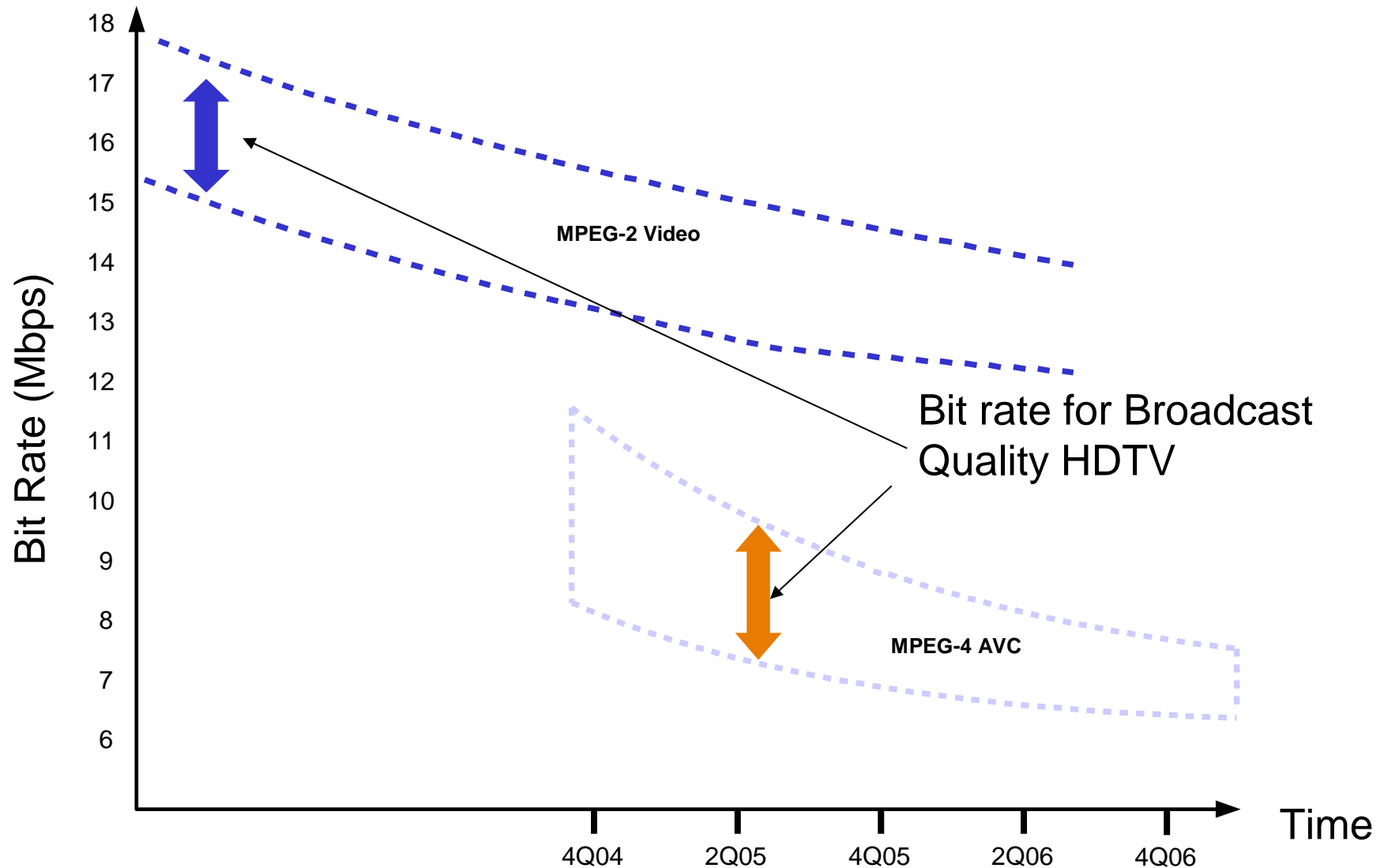
**Calix**

ACCESS INNOVATION

External drivers are stimulating demand beyond 20 Mbps

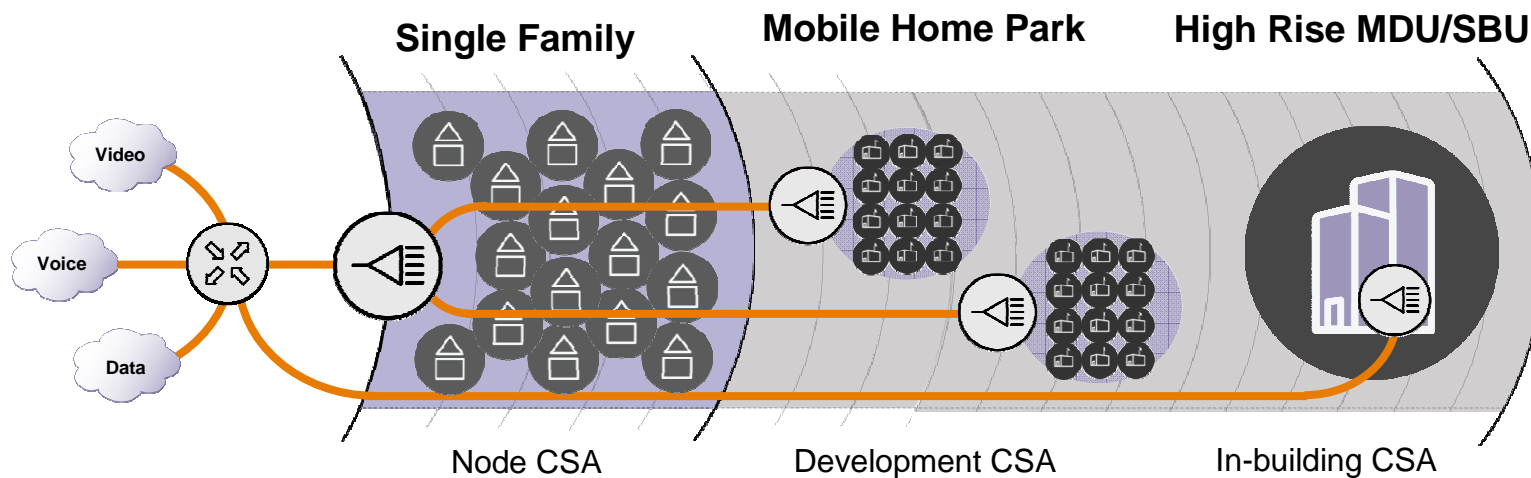






## VDSL2 enables broadband services for multiple applications

- ▶ Compelling, cost effective advanced services delivery
  - ▶ *High speed data & IPTV – platform / network ready for broadcast to unicast migration*
  - ▶ *Deliver lifeline POTS to the subscriber, carrier-grade VOIP to the network*
- ▶ Broadband optimized access platforms – CO, RT, Node or MDU
  - ▶ *Utilize VDSL2 for higher bandwidth on shorter loops*



## **Existing copper infrastructure in good shape**

- ◀ Less expensive than building new FTTH
  - ▶ *Drawback is the proliferation of outside plant cabinets*

## **Areas with high broadband penetration and market share**

- ◀ Remote cabinets are expensive to build, operate and power, so take rates make or break the business case

## **Areas without significant broadband competition**

- ◀ Areas not likely to be built with FTTH by a competitor
- ◀ Areas where cable is unlikely to upgrade to DOCSIS 3.0

## **High density housing and many MDUs**

- ◀ Brownfield MDUs are ideal for VDSL2; this is where VDSL2 has mostly been deployed outside the United States

## **VDSL2 band plans**

- ◀ Specifies frequencies utilized

## **Profile information**

- ◀ Specifies transmit power (dB) levels and frequency range (bandwidth) based on CSA (CO, RT, node) location
- ◀ Enables easy configuration of VDSL2 technology
- ◀ Profiles are new, not specified as part of VDSL1 standard

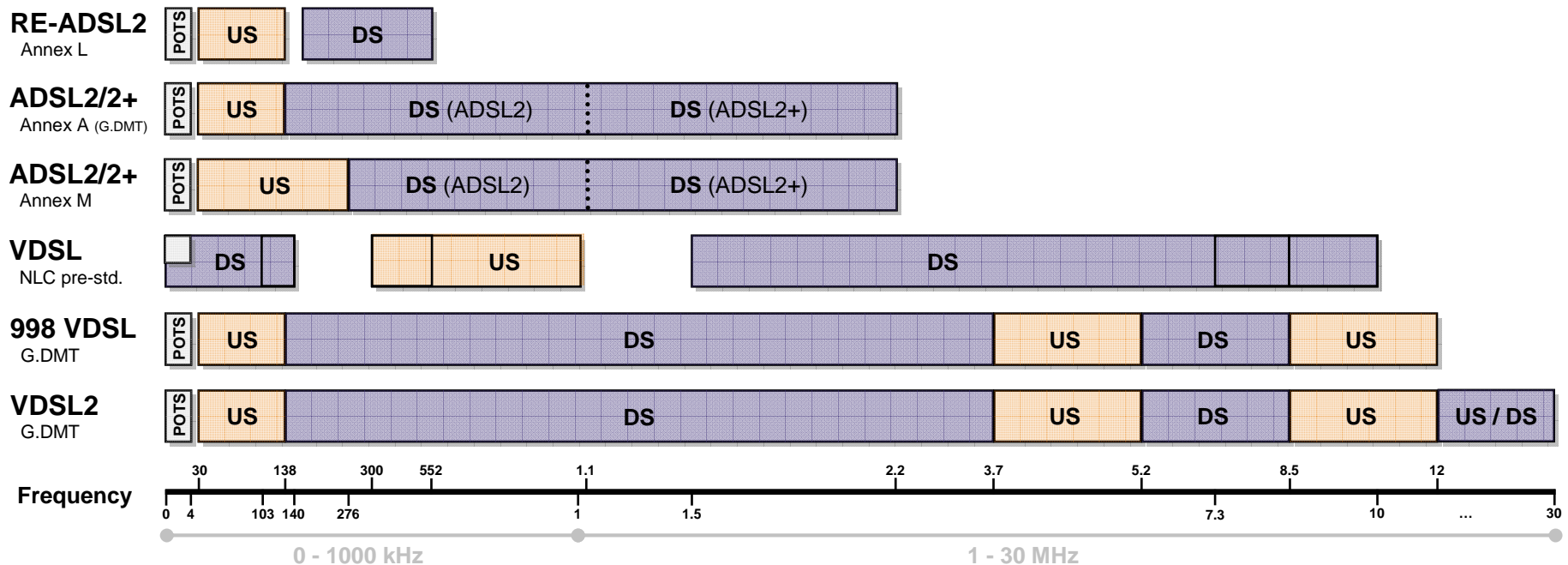
## **Profile optimization**

- ◀ Some profiles target CO's with strong ADSL crosstalk likelihood
- ◀ Others target RT locations with decreased TX power to avoid CO based DSL interference
- ◀ A third profile type is ideal for MDU deployments – extremely high bandwidth over short distances



## DSL Spectrum Utilization

- ▶ Any access technology with frequency overlap is an interferer
  - ▶ High dB launch power generally means a greater likelihood of interference due to signal strength bleed-over and capacitive coupling between pairs
- ▶ DMT based DSL technology will provide best inter-binder performance



## VDSL2 profiles enable network deployment flexibility

- ▶ Profiles are optimized for specific deployment locations
  - ▶ Watch power transmit levels if inserting VDSL2 mid-span into a common binder

		Max. DS Power	Max. Freq. DS/US	Bandwidth (Max Downstream)	Bandwidth (Max Upstream)	Typical Application
Target - North American OSP	Profile 8b	20.5 dBm	8.5 / 5.2 MHz	60 Mbps	15 Mbps	CO
	Profile 8a	17.5 dBm	8.5 / 5.2 MHz	60 Mbps	15 Mbps	CO
	Profile 8d	14.5 dBm	8.5 / 5.2 MHz	60 Mbps	15 Mbps	RT
	Profile 8c	11.5 dBm	8.5 / 5.2 MHz	60 Mbps	15 Mbps	RT
	Profile 12a	14.5 dBm	8.5 / 12 MHz	80 Mbps	40 Mbps	Node
	Profile 12b	14.5 dBm	8.5 / 12 MHz	80 Mbps	40 Mbps	Node
Cluster CSA/MDU	Profile 17a	14.5 dBm	n/a	100 Mbps	50 Mbps	MDU
	Profile 30a	14.5 dBm	n/a	100 Mbps	100 Mbps	MDU

Note 1: Max VDSL2 upstream power is 14.5 dBm for all band plans / profiles

Note 2: ADSL and ADSL2/2+ all have max downstream power of 20.5 dBm (no profiles)

## Transmit power

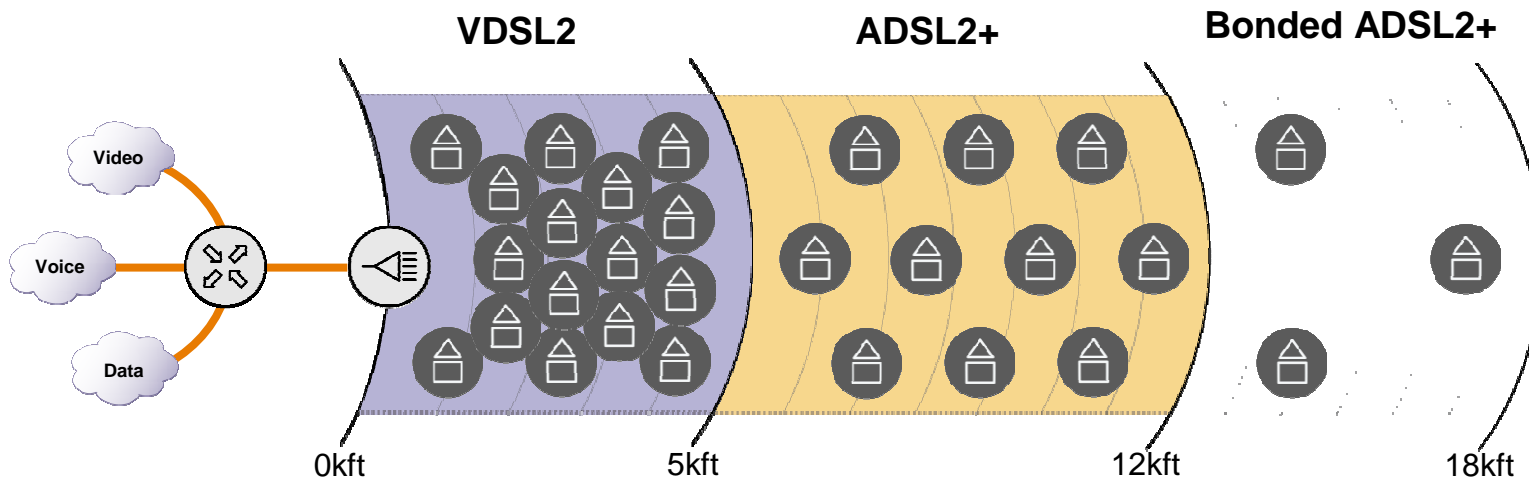
- ◀ Access platform power consumption increases with higher transmit power
- ◀ High bandwidth cannot be delivered with high transmit power due to cross-talk interference - limits the maximum usable bandwidth
- ◀ High transmit power typically increases noise due to increased noise power
  - ▶ *Lower frequencies have increased signal power limiting the impact of noise power*
  - ▶ *Profiles 12a, 12b, 17a and 30a don't allow transmit power higher than 14.5dBm*
- ◀ To achieve longer reach in the presence of crosstalk from legacy platforms, downstream transmit power can go as high as 20.5 dBm

## ADSL2+ fallback

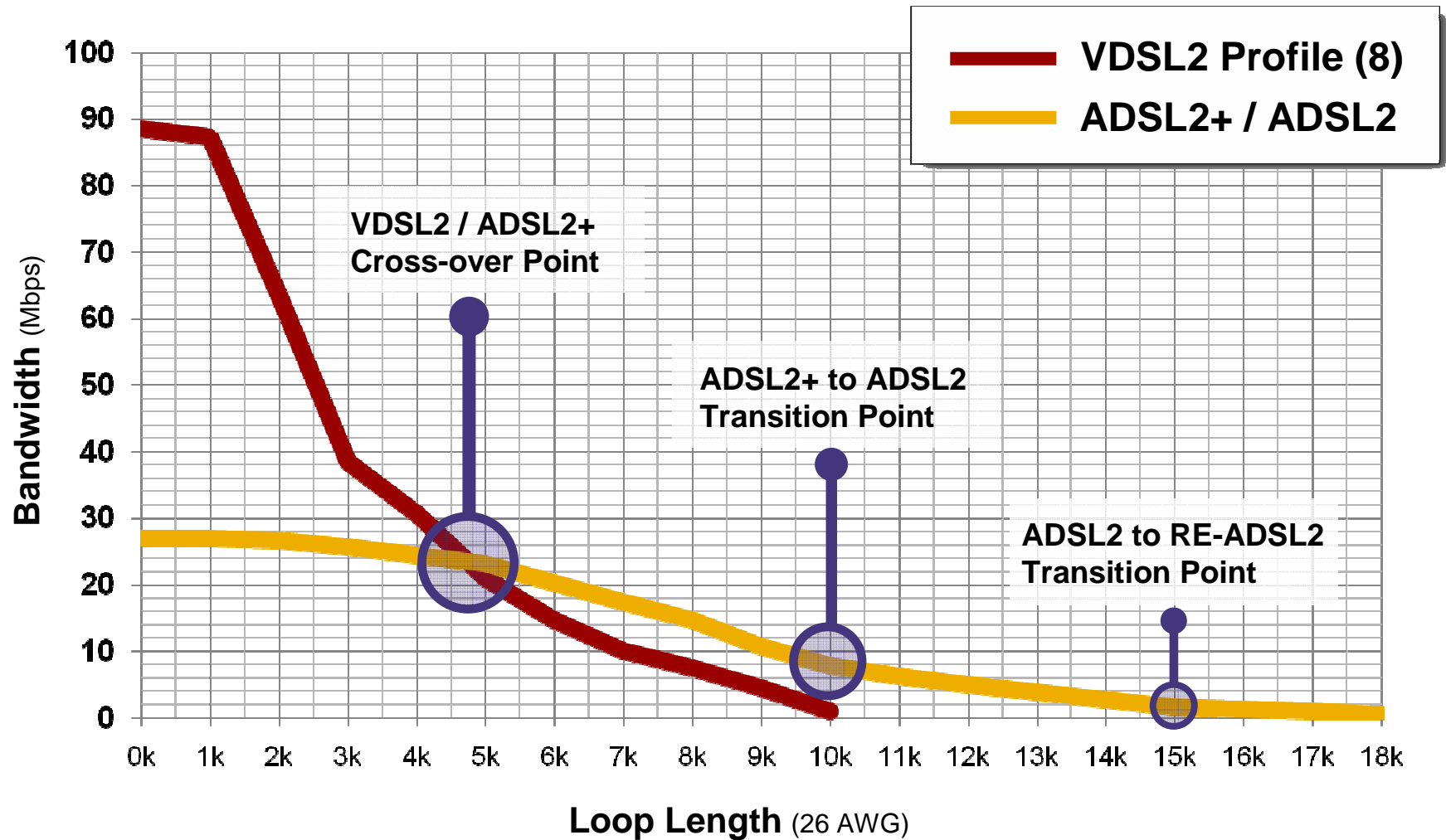
- ◀ Operation Modes: Forced VDSL2, Forced ADSL2+, Auto-Mode (fallback)
  - ▶ *Auto-Mode allows the DSLAM to attempt VDSL2*
    - ▶ *If it cannot connect satisfactorily it will try ADSL2+*
  - ▶ *Auto-Mode also enables the CO to attempt to train up at VDSL2*
    - ▶ *If CPE doesn't support VDSL2 then it attempts to train up at ADSL2+*
  - ▶ *For Auto-Mode (fallback) to work correctly, VDSL2 VLANs and ADSL2+ ATM PVC's must both be pre-provisioned*
  - ▶ *Several early VDSL2 CPE only support VDSL2 (no fallback)*

## VDSL2 fallback to ADSL2+ greatly enlarges service areas

- ✦ Flexible approach to broadband service delivery
  - ▶ Utilize VDSL2 for higher bandwidth on shorter loops
  - ▶ Use ADSL2+ fallback for longer loops
  - ▶ Utilize DSL loop bonding to edge out challenging CSAs, increase broadband bitrates

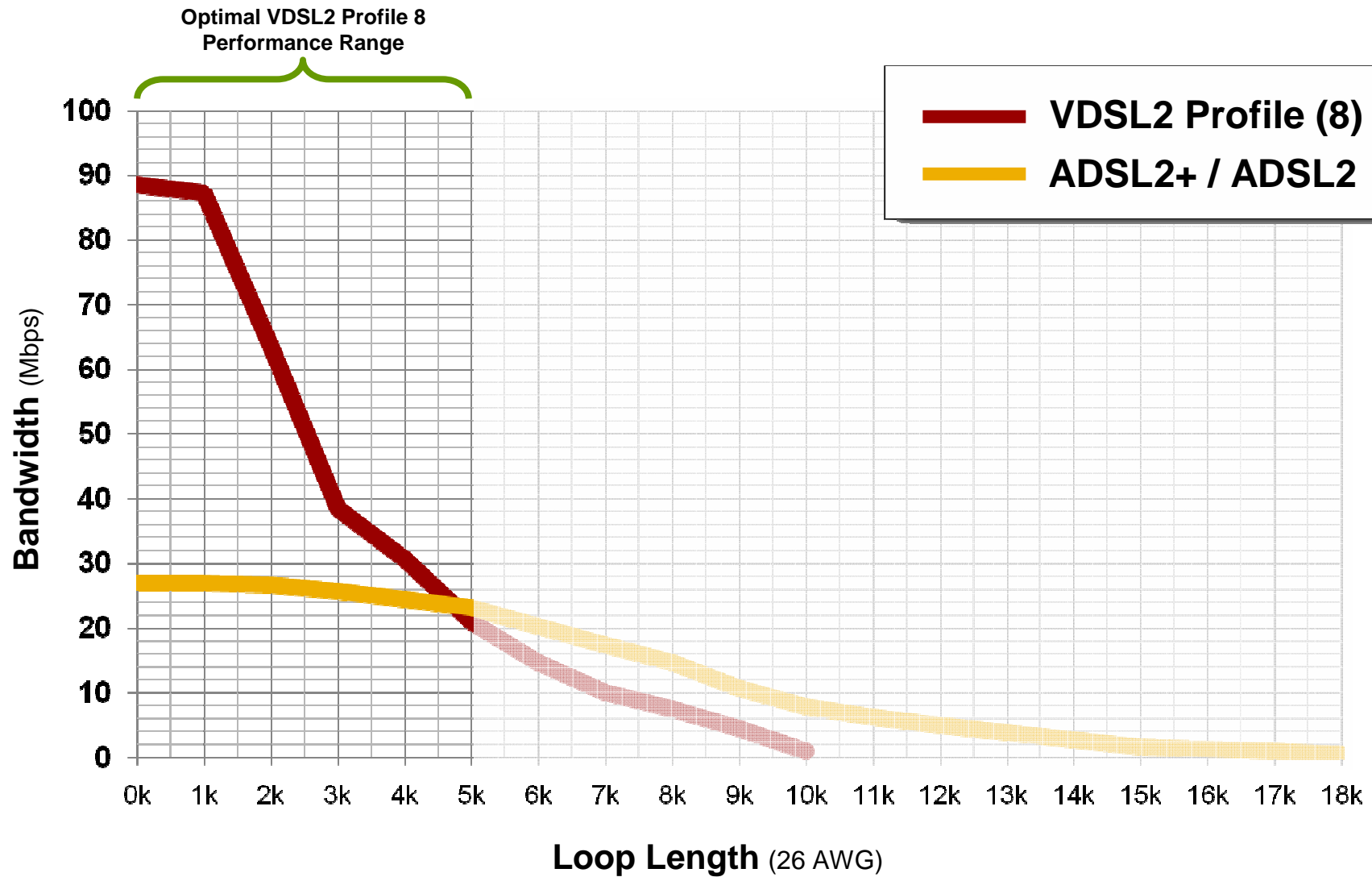


# DSL Loop Lengths (downstream)

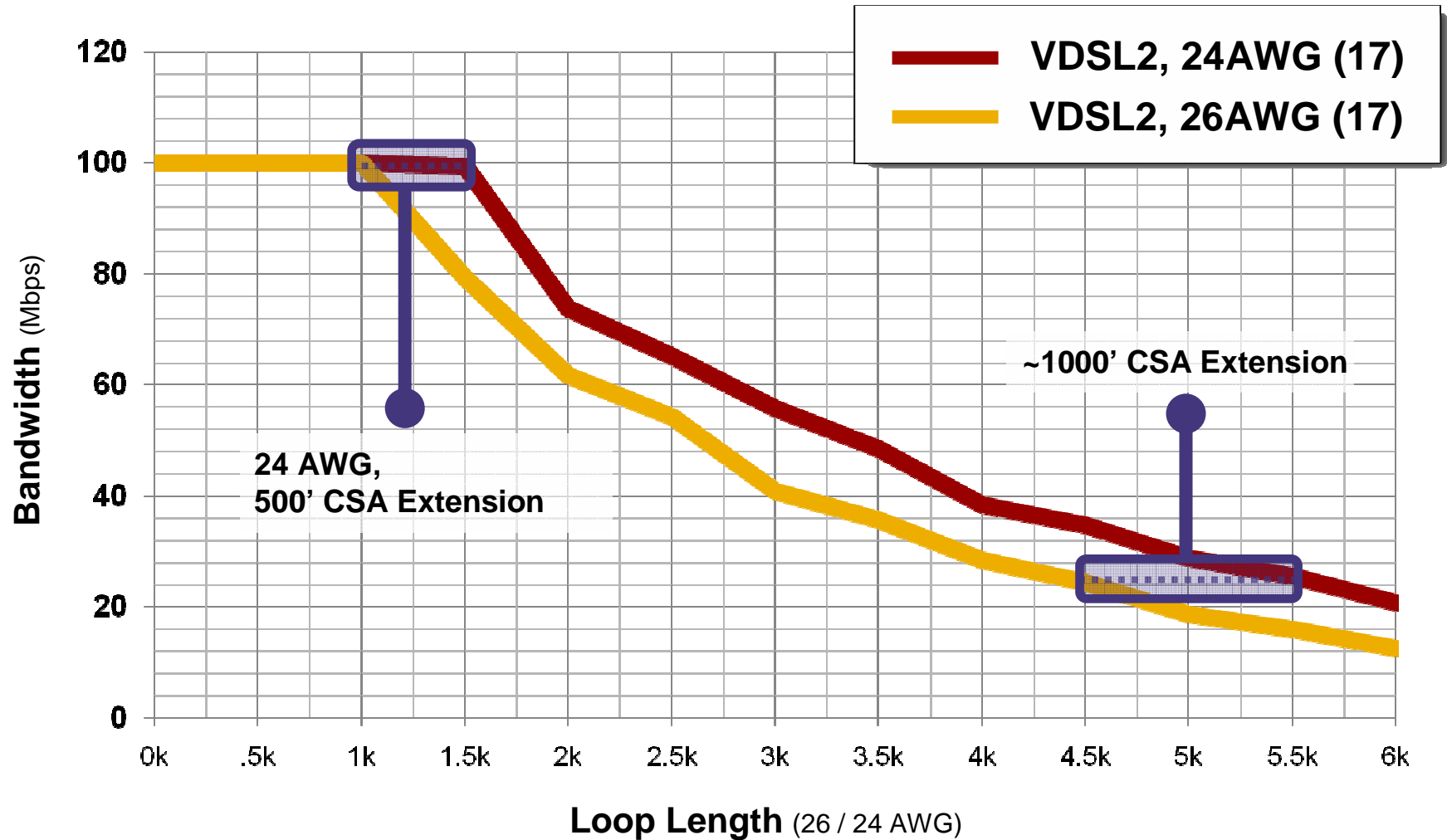


Note: Graph reflects test results captured with matched chipsets. (Results may vary)

# *VDSL2 Sweet Spot (downstream)*



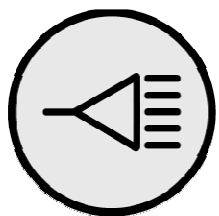
Note: Graph reflects test results captured with matched chipsets. (Results may vary)



Note: Graph reflects test results captured with matched chipsets. (Results may vary)

## Broadband DSL pair bonding

- ▶ Bonding enables logical bonding of physical copper pairs
  - ▶ Simplifies service delivery / provisioning across pairs
  - ▶ Reduces troubleshooting activities when multiple pairs are involved
- ▶ Loops supported with G.Bond technology
  - ▶ Up to two pairs with ADSL2+ (G.998.1 – ATM mode)
  - ▶ Up to eight pairs with VDSL2\* (G.998.2 – packet mode)



**G.Bond technology logically groups pairs and achieves 85+% bonded loop bandwidth capacity / throughput**

(Bonding overhead/mgt., SNR/AWG differential, interference prevention, etc.)

85+%  
Capacity

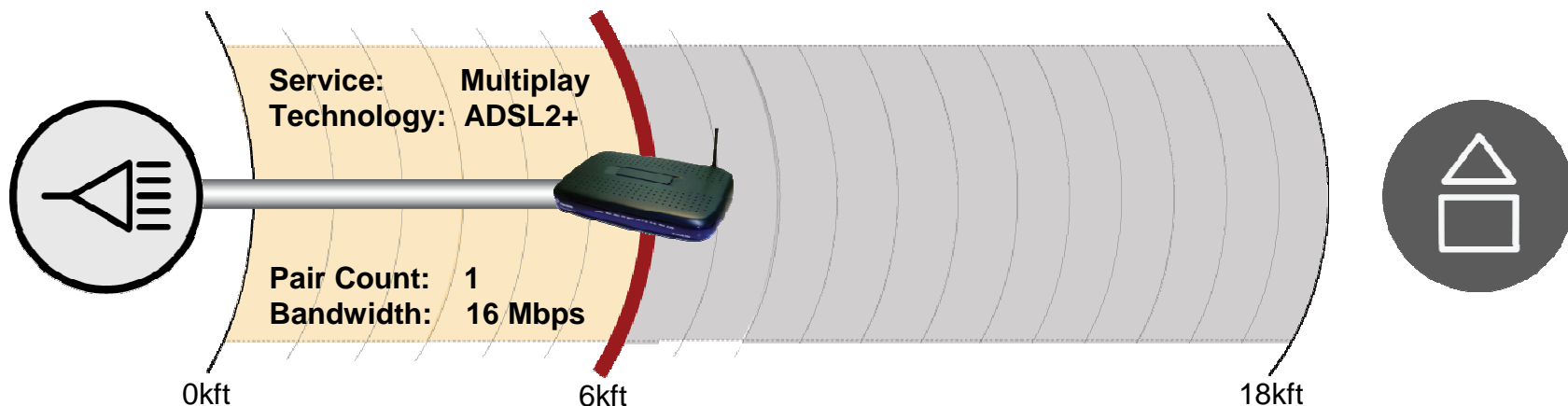


\* Future E5 platform release availability



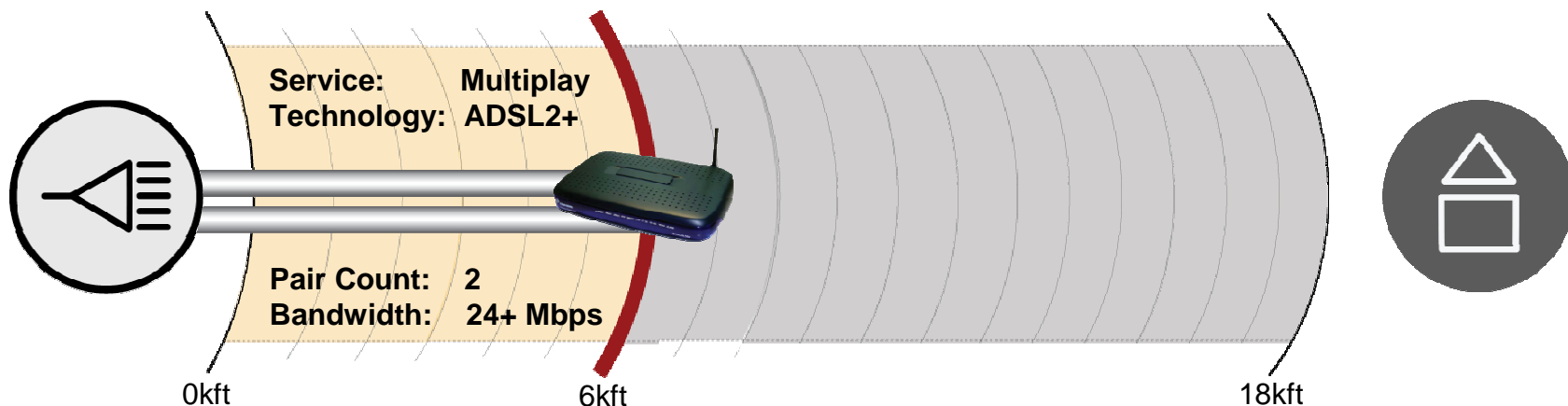
### Traditional multiple service offering (voice, video, data)

- ▶ Bandwidth requirements are driven by local competition and bandwidth intensive applications (ex: IPTV or broadband video)
- ▶ Most multiple service providers deploy 5kft – 6kft CSAs for traditional ADSL2+ offerings
  - ▶ Enables common service delivery baseline of 14-20 Mbps
- ▶ Low cost ADSL2+ modems are widely available



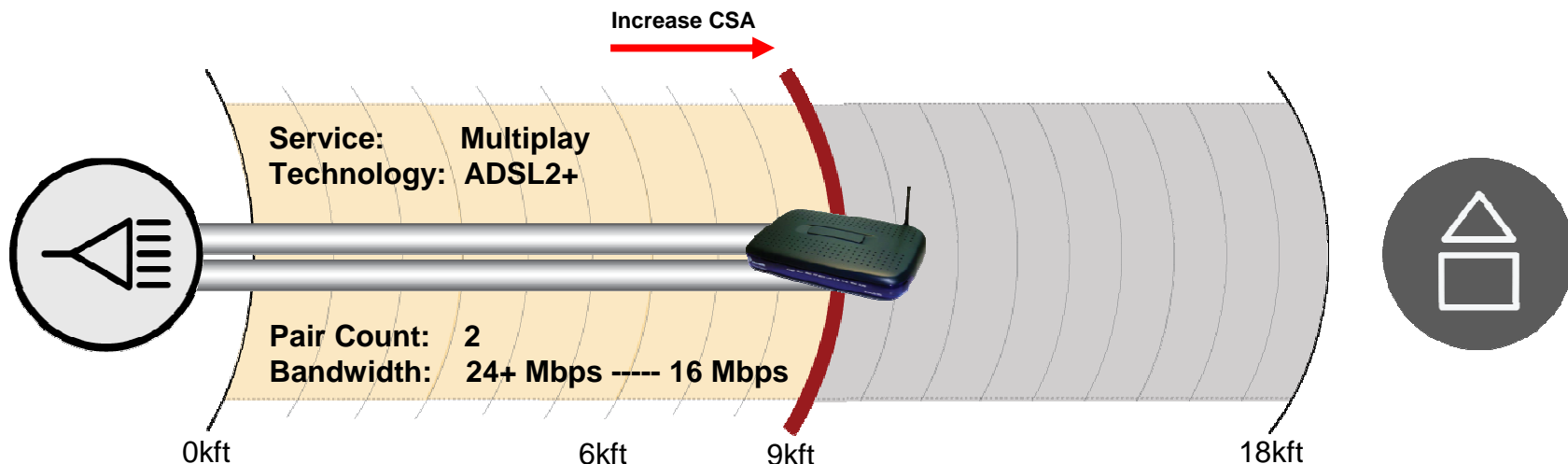
## Use bonding to increase bandwidth within an existing CSA

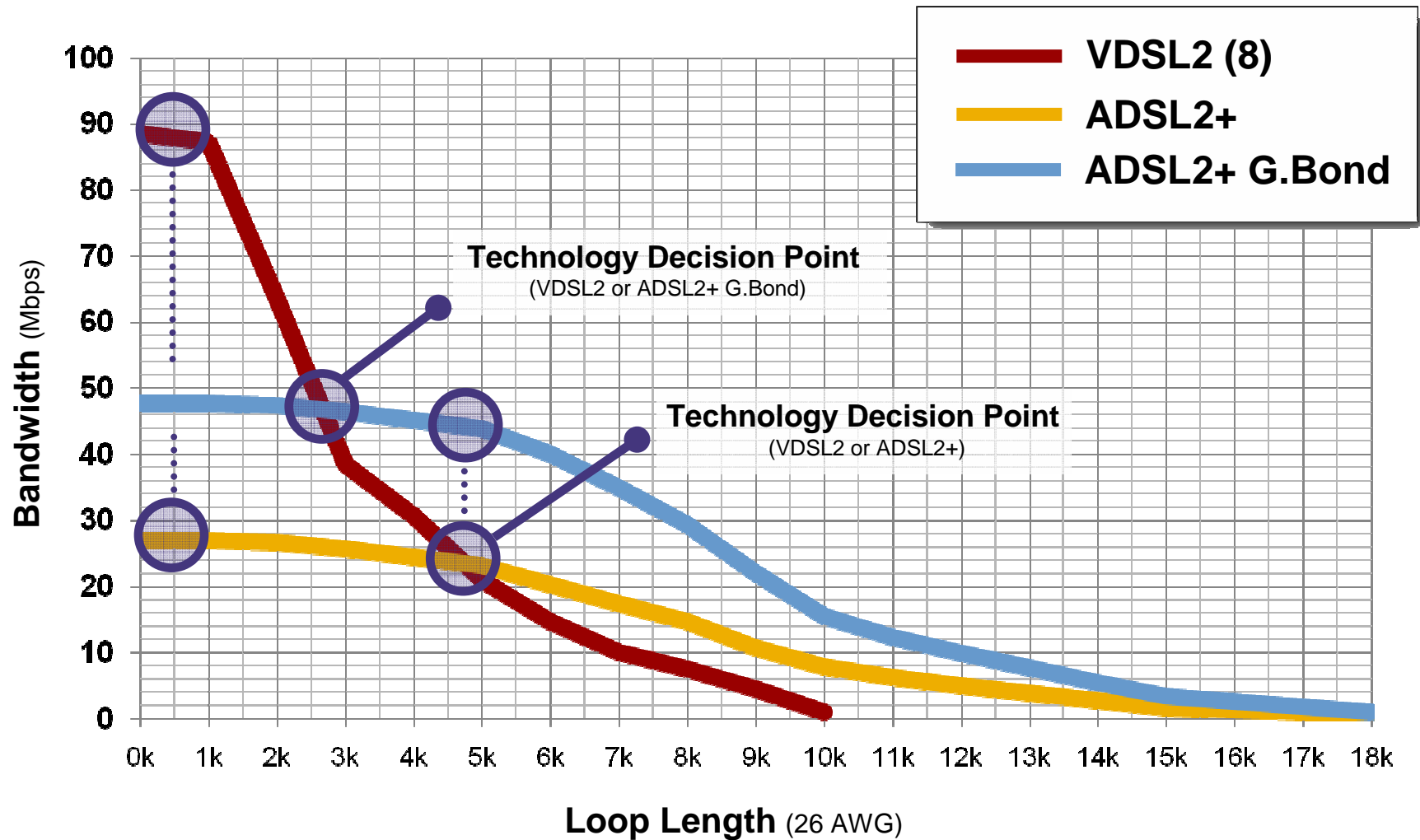
- ▶ IPTV services (HDTV or HD VOD) may require bandwidth not achievable on a single pair
- ▶ G.Bond technology allows two pairs to be provisioned and managed as a single logical pair
  - ▶ *Scenario: 6kft CSA loops can attain 14-20 Mbps on individual pairs (AWG, cable condition, noise, etc. impact loop performance)*
  - ▶ *Bonding: Two ADSL2+ pairs will deliver 24+ Mbps to the subscriber at 6kft*



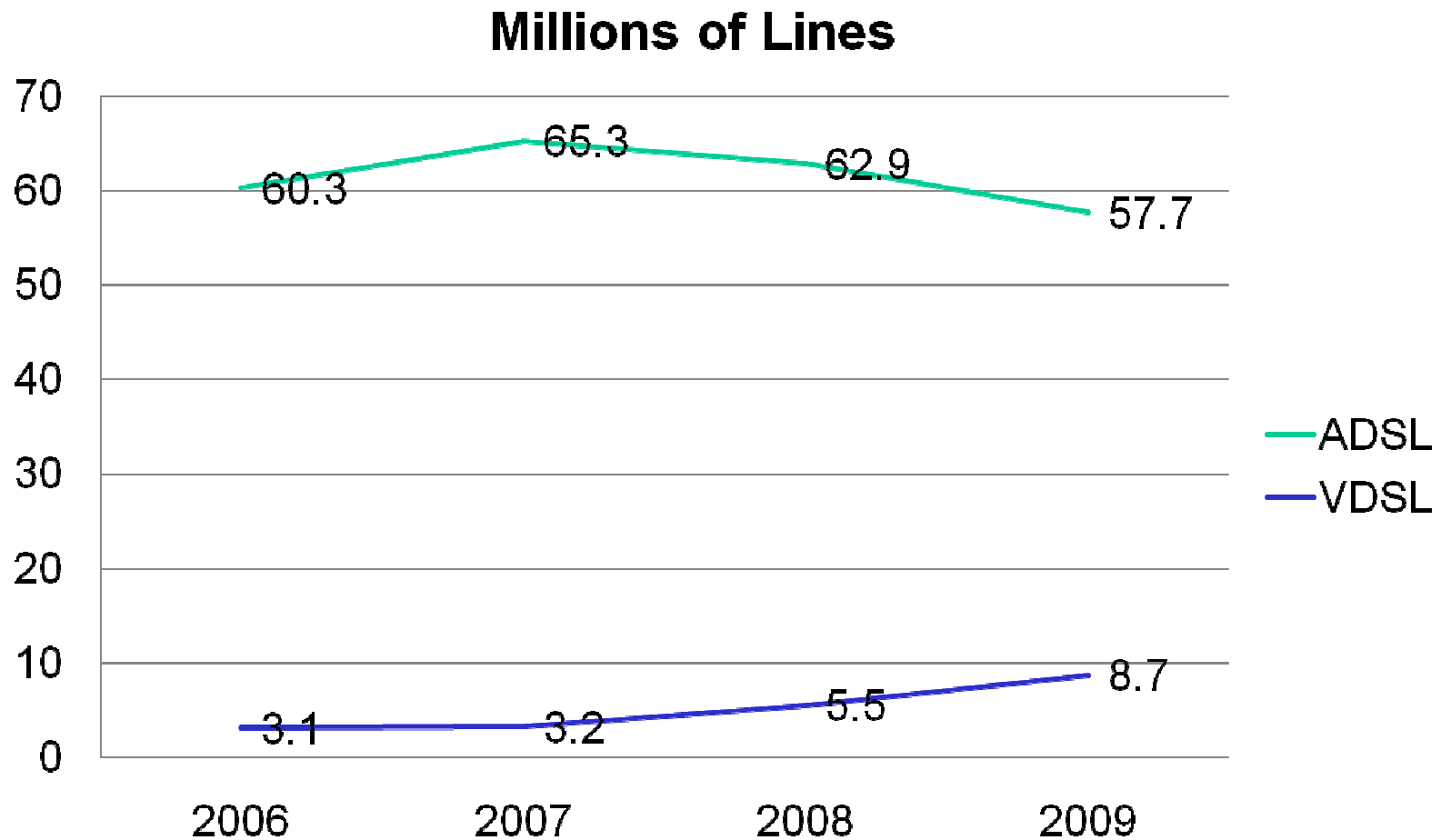
## Use bonding to extend CSA, maintain bandwidth baseline

- ▶ IPTV services (HDTV or HD VOD) may require bandwidth not achievable on a single pair
- ▶ Enables service provider to edge out their access network or provide service at the access network edge
  - ▶ Scenario 1: 6kft CSA loops can attain 14-20 Mbps, 9kft CSA loops can attain 8-12 Mbps on individual pairs (AWG, cable condition, noise, etc. impact loop performance)
  - ▶ Bonding: Two G.Bond pairs will deliver 24+ Mbps at 6kft or 15+ Mbps at 9kft



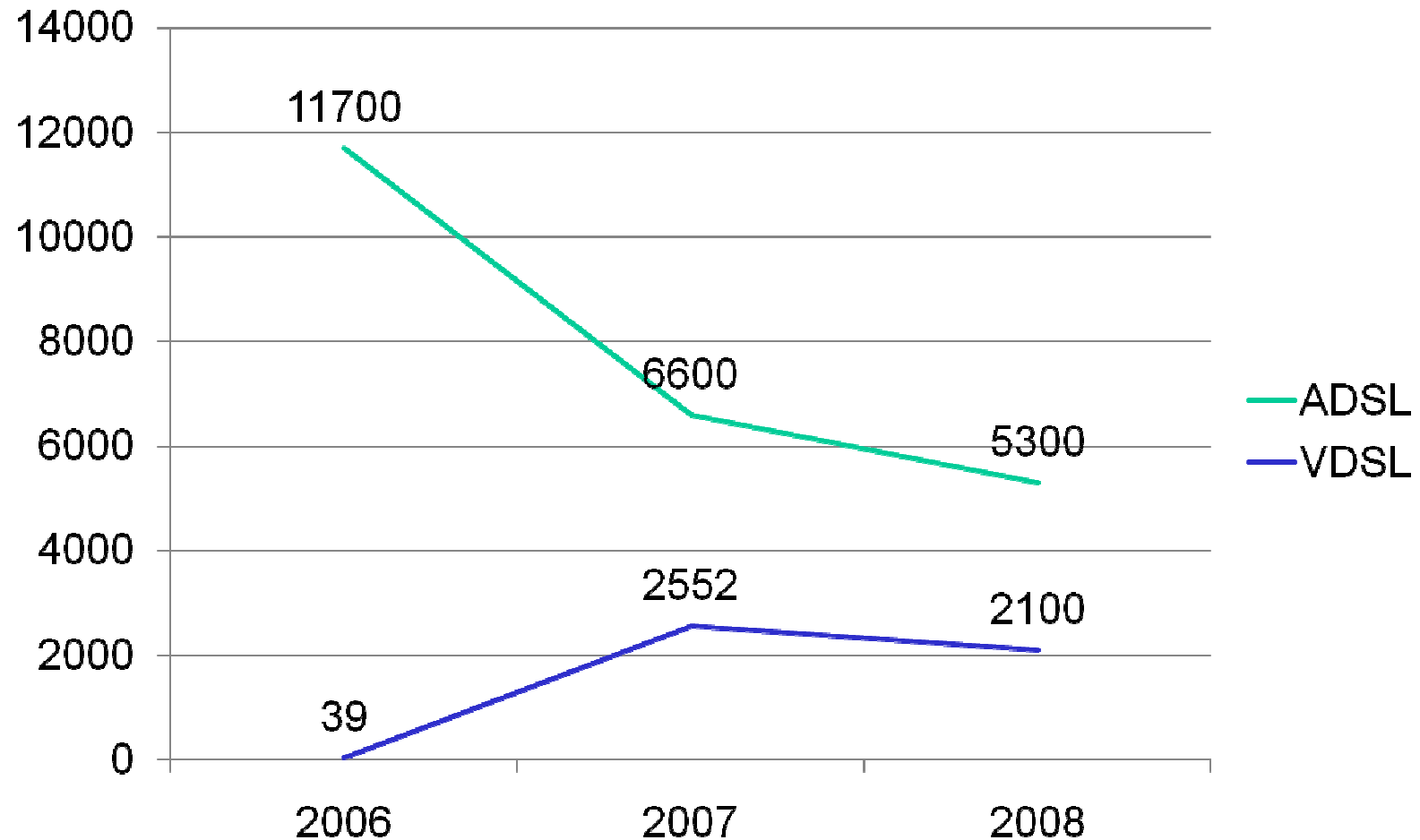


Note: Graph reflects test results captured with matched chipsets. (Results may vary)



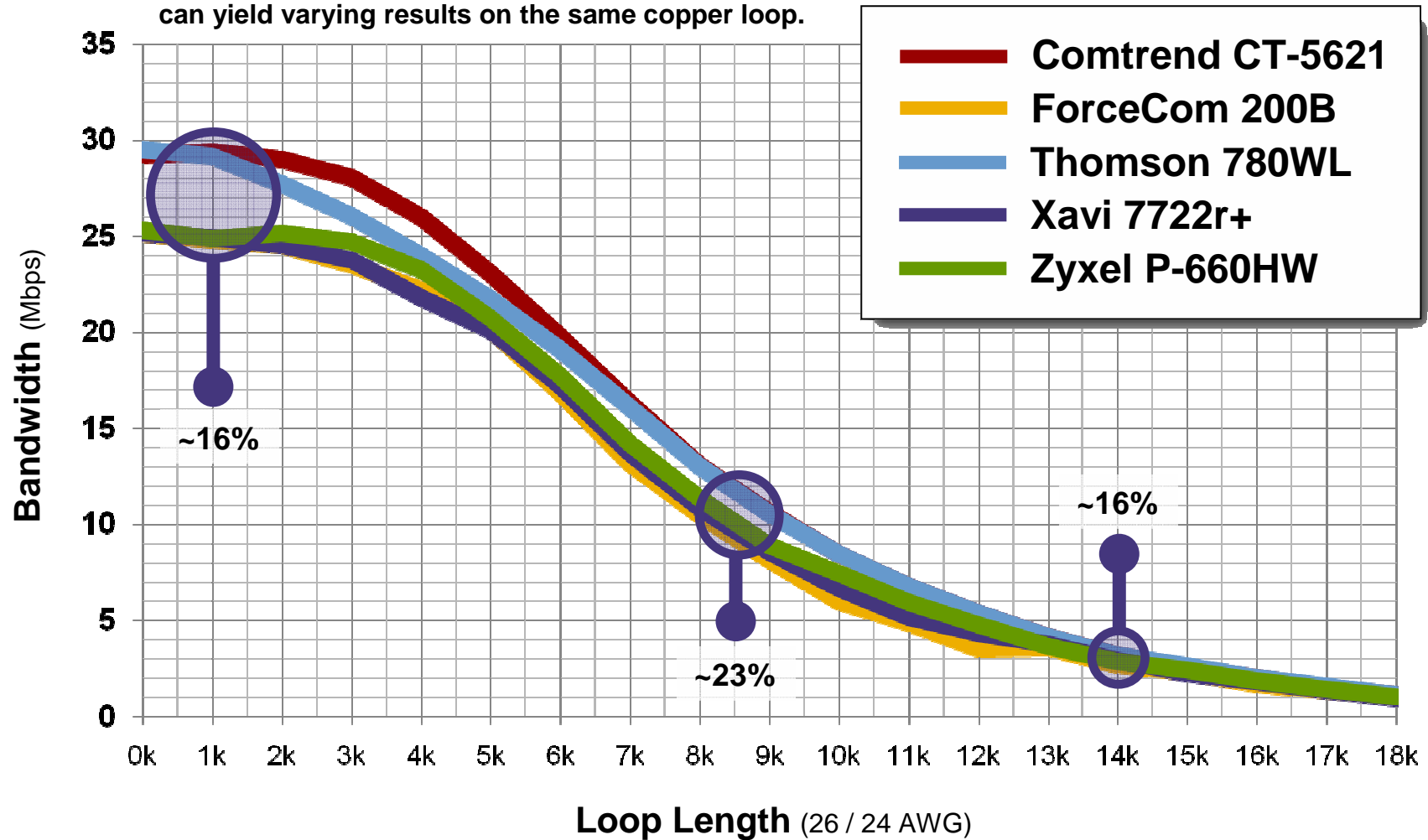
Source: Dell'Oro, December 2008

### Millions of Lines



Source: Dell'Oro, December 2008

Different modem, chipset or firmware combinations can yield varying results on the same copper loop.

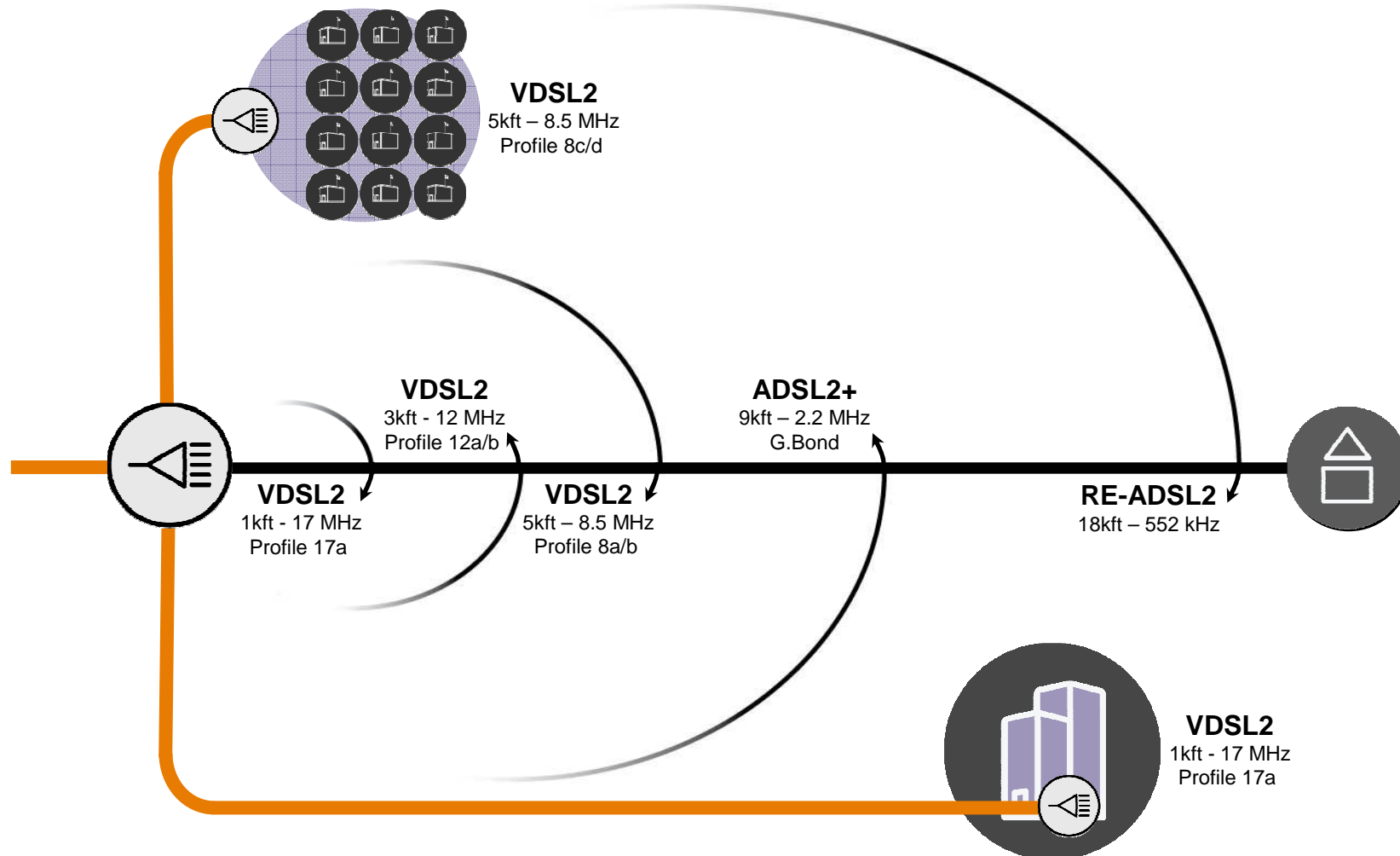


Note: Graph depicts a representative example of modem train rates and sample chipset pairings – results may vary.  
Due to loop plant variables, continual firmware enhancements, and routine modem optimizations, this graph is not intended to show current modem performance data.

## **So what DSL profiles are best?**

- ▶ ADSL2+ for traditional DLCs or loops greater than 5kft
- ▶ ADSL2+ Annex M for 1.5 Mbps symmetrical services up to 9kft
- ▶ ADSL2+ G.Bond Annex M for 3 Mbps symmetrical services up to 9kft
- ▶ ADSL2+ G.Bond for high capacity asymmetrical bandwidth requirements (IPTV) for loops between 5kft and 9kft
- ▶ VDSL2 (Profile 8a/8b) for loops with mixed ADSL2+ and VDSL2 launched from same location (ex: CO)
- ▶ VDSL2 (Profile 8c/8d) for loops with mixed ADSL2+ (over 5kft) and VDSL2 (under 5kft)
- ▶ VDSL2 (Profile 12a/12b) for loops under 3kft – large / medium node or housing / business development
- ▶ VDSL2 (Profile 17a) for loops under 1kft – small node or MDU application





# Thank You

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The information contained in this presentation is not a commitment, promise or legal obligation to deliver any material, code or functionality. The development, release, and timing of any features or functionality described for our products remains at our sole discretion.



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ACCESS INNOVATION